IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SK INNOVATION CO., LTD., Plaintiff, v. LG CHEM, LTD., LG ENERGY SOLUTION MICHIGAN, INC., AND LG ENERGY SOLUTION, LTD., Defendants.	C.A. No. 19-cv-1638-CFC **DEMAND FOR JURY TRIAL**

AMENDED COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff SK Innovation Co., Ltd. ("SK Innovation") files this Complaint for patent infringement under 35 U.S.C. § 271 against LG Chem, Ltd., LG Energy Solution, Ltd. ("LGES"), and LG Energy Solution Michigan, Inc. ("LGESM") (each a "Defendant" and collectively "LG Chem" or "Defendants") and alleges as follows:

OVERVIEW

1. This is a civil action for infringement of U.S. Patent No. 10,121,994 ("the '994 Patent") under the patent laws of the United States, 35 U.S.C. §§ 1, *et seq*.

2. SK Innovation was founded in 1962 in South Korea, known then as the Korea Oil Corporation. SK Innovation was Korea's first and is currently Korea's largest energy-chemical company. SK Innovation and its subsidiaries (including SK Battery America, Inc.) have over 6,500 employees world-wide. In a sign of its confidence in the United States' burgeoning electric vehicle market, in 2018, SK Innovation announced that it was planning to spend over $1 billion to build its first electric vehicle battery plant in the United States, with an annual capacity of 9.8

gigawatt-hours of batteries. The battery plant has been under construction in Georgia since the groundbreaking ceremony in March 2019.

3. Since its founding over 50 years ago, SK Innovation has led Korea's energy industry through ceaseless innovation and technology development and is recognized as a global leader in new energy technologies, in particular for electric vehicle ("EV") batteries. SK Innovation was the first company to successfully apply high energy density ternary materials to lithium-ion batteries for mass production in the EV battery industry. Based on its superior technological capabilities, SK Innovation has worked with major global automakers since 2010 to provide EV batteries for the global market. For example, SK Innovation was selected by Hyundai to provide batteries for its BlueOn, Korea's first electric vehicle, and for the KIA Ray. Mercedes-AMG, Daimler-AG's high-performance automobile division, selected SK Innovation to supply batteries for the SLS AMG E-cell vehicle, Mercedes-AMG's first electric car.

4. SK Innovation is a leading researcher and developer across the entire value chain for mid/large-sized battery production, ranging from electrodes and separators to battery cells, battery modules and battery packs. SK Innovation's battery products are used throughout the world in electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), hybrid vehicles (HEVs), universal power supplies (UPS), renewable energy projects, and smart grids.

5. SK Innovation and its subsidiaries currently have over 1,000 U.S. patents and patent applications covering SK Innovation's various business areas. A part of SK Innovation's patent portfolio relates to chemical electrical technologies, and in particular the lithium-ion battery technology that is the subject of this Complaint.

PARTIES

6. Plaintiff SK Innovation is a corporation organized and existing under the laws of South Korea, and maintains its principal place of business at 26 Jong-ro, Jongno-gu, Seoul 03188, South Korea.

7. On information and belief, Defendant LG Chem, Ltd. is a South Korean corporation with its principal place of business at 128 Yeoui-daero, Yeongdeungpo-gu, Seoul 07336, South Korea.

8. On information and belief, Defendant LG Energy Solution, Ltd. is a corporation organized under the laws of South Korea, having a principal place of business at 108 Yeoui-daero, Yeongdeungpo-gu, Seoul 07335, South Korea.

9. On information and belief, Defendant LG Energy Solution Michigan, Inc. is a corporation organized under the laws of the State of Delaware and maintains its principal place of business at 1 LG Way, Holland, Michigan 49423. On information and belief, LGESM is a wholly-owned subsidiary of LG Energy Solution, Ltd. and was formerly named LG Chem Michigan, Inc., until its name was changed to LG Energy Solution Michigan, Inc. on or about December 1, 2020. On information and belief, LGESM may be served with process through its registered agent Corporation Service Company at 251 Little Falls Drive, Wilmington, Delaware 19808.

10. LG Chem, Ltd., LG Energy Solution, Ltd., and LG Energy Solution Michigan, Inc. are referred to collectively as "LG Chem."

JURISDICTION AND VENUE

11. This Court has exclusive subject matter jurisdiction over this case under 28 U.S.C. §§ 1331 and 1338.

12. Venue is proper in this Court under 28 U.S.C. §§ 1391 and 1400(b). Defendants LG Chem, Ltd. and LG Energy Solution, Ltd. are foreign entities, and thus, venue is proper in this judicial district. On information and belief, Defendant LG Energy Solution Michigan, Inc. resides in this judicial district. On information and belief, all of the Defendants have committed acts of infringement in this judicial district, and have purposefully transacted business involving the accused products in the United States and this judicial district.

13. This Court has personal jurisdiction over the Defendants because (1) SK Innovation's claims arise in whole or in part from Defendants' conduct in the State of Delaware; (2) LG Chem, Ltd. has sought the protection and benefit from the laws of the State of Delaware and regularly conducts business in the State of Delaware by incorporating subsidiaries, including LG Energy Solution Michigan, Inc., in the State of Delaware; (3) All of the Defendants regularly conduct business throughout the United States, including the State of Delaware, and contract to supply services or things in Delaware; (4) All of the Defendants have contacts purposefully directed at the United States and the State of Delaware and have continuous and systematic contacts with the United States and the State of Delaware; (5) All of the Defendants have placed infringing products into the stream of commerce through an established distribution channel with the expectation or knowledge that they will be purchased by consumers in the United States and the State of Delaware; and (6) All of the Defendants have caused tortious injury in the State of Delaware.

14. LG Chem, Ltd. has maintained a United States version of its website at https://www.lgchem.com/us/main. On this website, LG Chem, Ltd. provides information regarding its activities and products, including LG Chem, Ltd.'s Automotive Batteries, which include the infringing secondary batteries and systems. On information and belief, LG Chem,

Ltd.'s website is directed to marketing, offering for sale, and sales of its products and services in the United States and in the State of Delaware.

15. LG Energy Solution, Ltd. maintains an English version of its website at https://www.lgensol.com/en/company. On this website, LGES provides information regarding its activities and products, including information relating to its manufacturing facility in Holland, Michigan. On information and belief, LGES's website is direct to marketing, offering for sale, and sales of its products and services in the United States and in the State of Delaware.

16. Defendants LG Chem, Ltd. and LG Energy Solution, Ltd. have also derived benefits from the laws of the United States. For example, Defendants LG Chem, Ltd. and LG Energy Solution, Ltd. have filed litigations in the United States, including based on claims for patent infringement. On information and belief, Defendants LG Chem, Ltd. and LG Energy Solution, Ltd. derive substantial revenues from their regularly conducted business activities throughout the United States and the State of Delaware. On information and belief, Defendant LG Chem, Ltd. receives substantial revenue from its activities and the activities of its U.S. subsidiaries in the United States. On information and belief, Defendant LG Chem, Ltd. is in regular contact with their subsidiaries and affiliates in the United States and direct communication into the United States.

THE ASSERTED PATENT

17. On November 6, 2018, the '994 Patent was duly and legally issued for an invention titled "Secondary Battery and Method for Manufacturing the Same." The '994 Patent claims priority to Korean Patent Application 10-2015-0091847, filed June 29, 2015. SK Innovation owns all rights to the '994 Patent necessary to bring this action, including the exclusive right to recover for past infringement. A true and correct copy of the '994 Patent is attached as Exhibit 1.

18. The ’994 Patent generally relates to a secondary battery device, which may serve as the power source for EVs, HEVs, and PHEVs. The inventive design of the secondary battery disclosed in the ’994 Patent solves problems associated with the thickness and energy density of secondary batteries. An embodiment of the ’994 Patent includes an exterior material that includes, among other things, a pouch film and a sealing portion formed at an outer side of the pouch film. In this embodiment of the secondary battery, an electrode assembly may be housed by two forming portions within the pouch film. In this embodiment, the secondary battery may be formed by placing one side of the electrode assembly within one forming portion, and then wrapping the other side of the electrode assembly with the other forming portion. In this embodiment, a predetermined space interval T may be formed between the pair of forming portions. In this embodiment, the thickness of the space, in which the electrode assembly is received, may be increased by as much as the predetermined interval T. The maximum thickness of the electrode assembly in this embodiment is T+2f, where f is the depth of each of the forming portions.

GENERAL ALLEGATIONS

19. The products that infringe one or more claims of the ’994 Patent (the “Accused Products”) include, but are not limited to, secondary battery cells that are made by LG Chem.

20. On information and belief, LG Chem has and continues to at least indirectly infringe one or more claims of the ’994 Patent in violation of 35 U.S.C. § 271 (b).

21. On information and belief, LG Chem may have directly infringed and/or contributed to the infringement of, and may continue to infringe and/or contribute to the infringement of, one or more claims of the ’994 Patent in violation of 35 U.S.C. § 271 (a) and (c) at least based on its activities in Michigan, for which SK Innovation reserves the right to assert claims of direct and/or contributory infringement.

22. Defendants are knowledgeable about the '994 Patent and infringing acts at least as of the date on which they are properly served with this Complaint.

23. Defendants' acts of infringement have caused damage to SK Innovation. SK Innovation is entitled to recover from Defendants the past damages sustained by SK Innovation as a result of Defendants' wrongful acts in an amount subject to proof at trial. SK Innovation is also entitled to recover from Defendants a compulsory future royalty payable on each infringing product sold by Defendants following trial or that is not captured in the damages awarded to SK Innovation.

CLAIMS FOR PATENT INFRINGEMENT

24. SK Innovation identifies below at least one exemplary claim for the '994 Patent to demonstrate infringement by exemplary products. However, the selection of exemplary claims and exemplary products should not be considered limiting, and additional infringing products and infringed claims of the '994 Patent will be disclosed in compliance with the Court's rules related to infringement contentions as discovery progresses.

COUNT I: PATENT INFRINGEMENT OF THE '994 PATENT

25. SK Innovation incorporates by reference the preceding paragraphs.

26. LG Chem at least induces third parties, including for example electric vehicle manufacturers such as Jaguar and Audi, to infringe one or more claims of the '994 Patent, including at least claim 1, either literally or under the doctrine of equivalents, by or through third parties' making, using, importing, offering for sale or selling electric vehicles containing the LG Chem Pouch Cell. On information and belief, LG Chem induces the direct infringement by automobile manufacturers by instructing, offering, or encouraging automobile manufacturers to use the infringing secondary battery cells in electrical vehicles and to import electrical vehicles

into the United States. Examples of such electric vehicles include the Jaguar I-PACE and the Audi e-tron®, which include the infringing LG Chem Pouch Cell.

27. On information and belief, LG Chem may have directly infringed and/or contributed the infringement of, and may continue to infringe and/or contribute to the infringement of, one or more claims of the '994 Patent at least based on its activities in Michigan, for which SK Innovation reserves the right to assert claims of direct infringement and/or contributory infringement. *See, e.g.*, *LG Chem, Ltd. v. SK Innovation Co., Ltd.*, 1:19-cv-00776 (D. Del. April 29, 2019), Complaint, ¶29 ("Specifically, LGCMI has research and development, testing and engineering, manufacturing, and business offices in Holland, Michigan, where it has invested hundreds of millions of dollars and employs hundreds of workers. LGCMI also has research and development, testing and engineering, manufacturing, sales and marketing, and business offices in Troy, Michigan, where it has invested many millions of dollars and employs hundreds of workers. Through its facilities in Michigan, LGC supplies millions of battery cells each year to automotive manufacturers including General Motors and Chrysler."); *LG Energy Solution, Ltd. et al. v. SK Innovation Co., Ltd. et al.*, 19-cv-1805-CFC, D.I. 12-1 (D. Del. Jan. 5, 2021) ("LGES has extensive involvement in the U.S. market with its innovative battery technology. In fact, LGES and its subsidiary LG Energy Solution Michigan[,] Inc. [ ] supply, through plants in Michigan[,] millions of battery cells to U.S. companies like General Motors and Chrysler. For example, LGESMI has invested hundreds of millions of dollars in a facility in Holland, Michigan, which employs hundreds of workers making lithium ion batteries for electric vehicles (EVs).").

28. LG Chem is knowledgeable about the '994 Patent and infringing acts at least as of the date on which it is properly served with this Complaint.

29. LG Chem's infringing acts have been without the permission, consent, authorization, or license of SK Innovation.

30. Claim 1 of the '994 Patent is recited below:

> 1. A secondary battery, comprising:
>
> an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film; and
>
> an electrode assembly which includes a plurality of electrode bodies laminated with a separator interposed therebetween,
>
> wherein a pair of forming portions are formed within the pouch film to house the electrode assembly, and
>
> wherein the electrode assembly is packaged by the exterior material in a manner that three sides of the exterior material are sealed and one side is not sealed, and a thickness of the electrode assembly is larger than a sum of each depth of the pair of forming portions.

31. The Accused Products embody the patented invention of the '994 Patent and infringe at least claim 1 of the '994 Patent. For example, the LG Chem Pouch Cell used in the Jaguar I-PACE and the Audi e-tron® infringes at least claim 1 of the '994 Patent.

32. On information and belief, the Jaguar I-PACE, an all-electric sports utility vehicle (SUV) made in the United Kingdom and imported into the United States, contains the infringing LG Chem Pouch Cell. *See, e.g.*, https://www.caranddriver.com/news/a19551959/preview-drive-2019-jaguar-i-pace-ev-keeps-it-simple/ (last accessed Feb. 5, 2021) ("That pack consists of 432 LG Chem lithium-ion pouch cells, assembled for Jaguar into 36 modules and a single pack by LG in Poland.").

33. On information and belief, the Audi e-tron®, an electric sports utility vehicle (SUV) made in Belgium and imported into the United States, contains the infringing LG Chem Pouch Cell. *See, e.g.*, https://chargedevs.com/features/audi-joins-the-class-of-2019-with-the-e-

tron/ (last accessed Feb. 5, 2021) ("The e-tron's battery pack stores 95 kWh of energy (83.6 kWh useable), and is made up of 36 modules, each containing 12 pouch-type lithium-ion cells from LG Chem.").

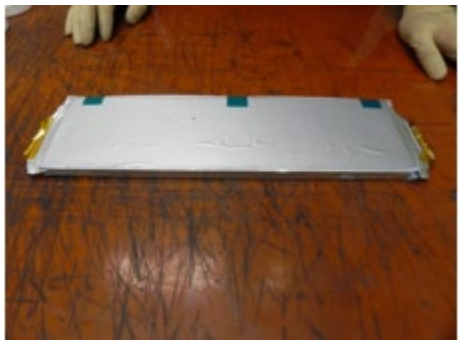
34. Since around 2018, the Jaguar I-PACE has been offered for sale in the United States, including in the State of Delaware, after being imported into the United States from the United Kingdom. A Jaguar dealership in Wilmington, Delaware, for example, advertises at least two Jaguar I-PACE vehicles that are located in the Wilmington, Delaware dealership and offered for sale or lease in the United States. *See* Union Park Jaguar, *New Inventory* (last accessed Feb. 5, 2021), *available at* http://www.unionparkjaguar.com/new-inventory/index.htm?reset=InventoryListing&make=Jaguar&model=I-PACE&search=SUV. The VIN number for one of the vehicles is listed as "SADHC2S12K1F75684." On information and belief, the first two characters (SA) indicate that the vehicle was assembled in the United Kingdom. *See* Union Park Jaguar, *2019 Jaguar I-Pace SE SUV* (last accessed Aug. 26, 2019), *available at* http://www.unionparkjaguar.com/new/Jaguar/2019-Jaguar-I-PACE-2aaccf800a0e0aea45594e05186b5e94.htm.

35. Since around 2019, the Audi e-tron® has been offered for sale in the United States, including in the State of Delaware, after being imported into the United States from Belgium. For example, an Audi dealership in Wilmington, Delaware, advertises that it has Audi e-tron® in stock for sale. *See* Audi Wilmington, *e-tron* (last accessed Feb. 5, 2021), *available at* https://www.audiwilmingtonde.com/audi-etron.htm.

36. As shown below, LG Chem's Pouch Cell is a secondary battery that contains an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film:

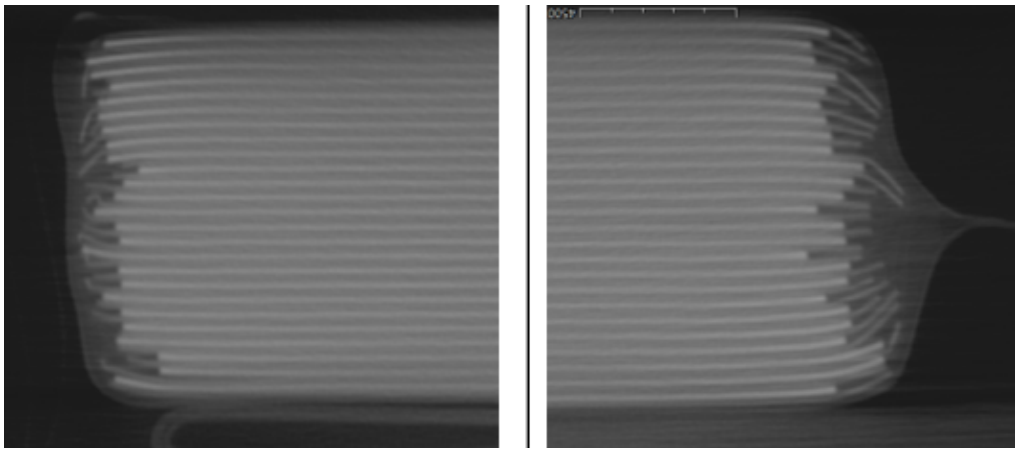
LG Chem's Pouch Cell in the Jaguar I-PACE:

LG Chem's Pouch Cell in the Audi e-tron®:

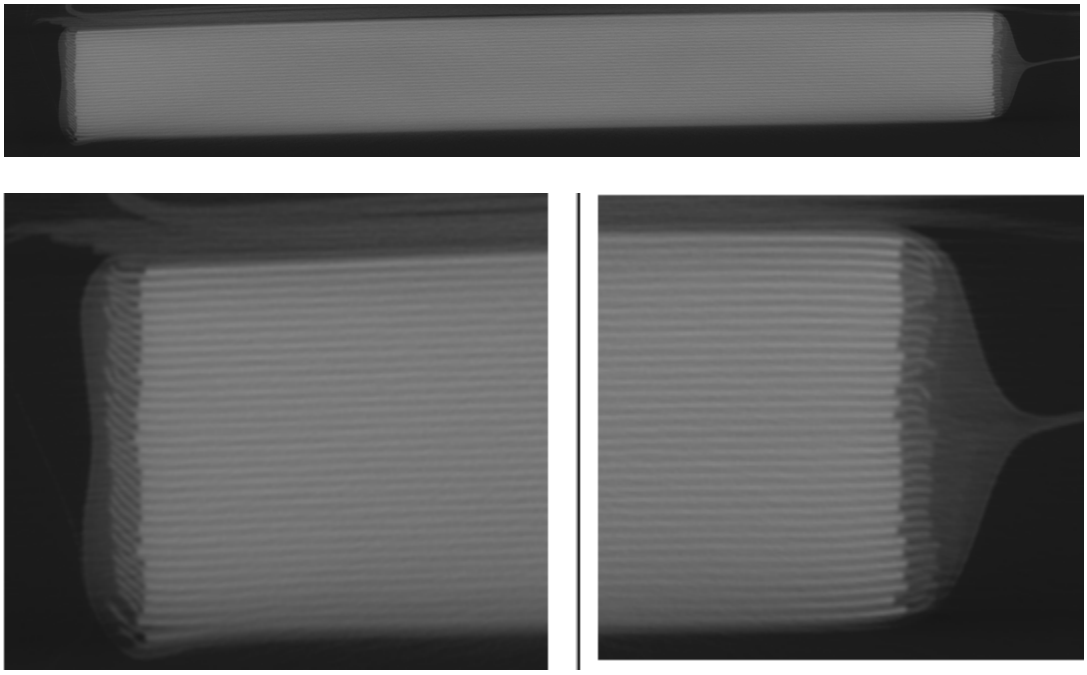


37. As shown below, LG Chem's Pouch Cell also includes an electrode assembly which includes a plurality of electrode bodies laminated with a separator interposed therebetween:

LG Chem's Pouch Cell in the Jaguar I-PACE:

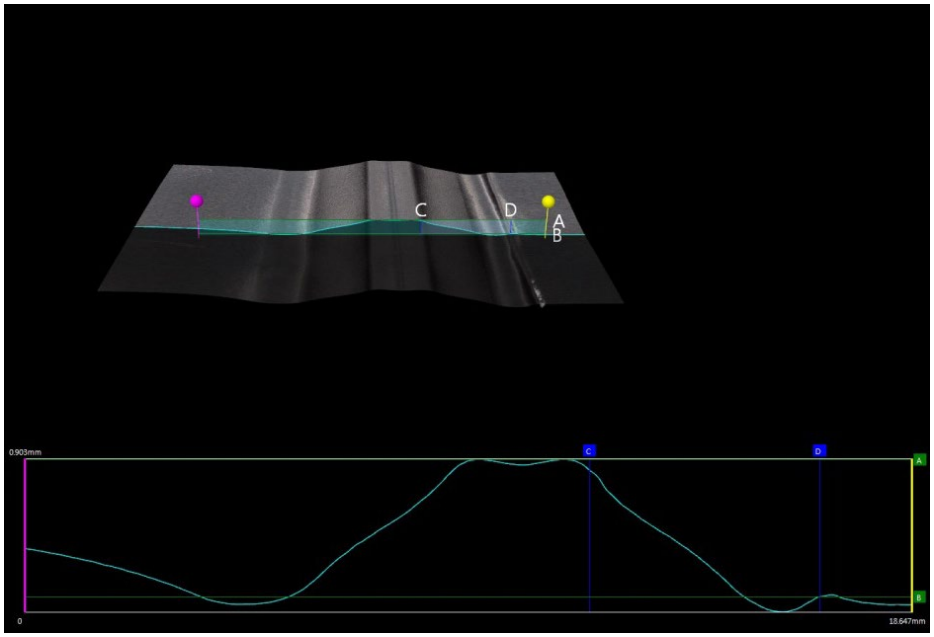


LG Chem's Pouch Cell in the Audi e-tron®:

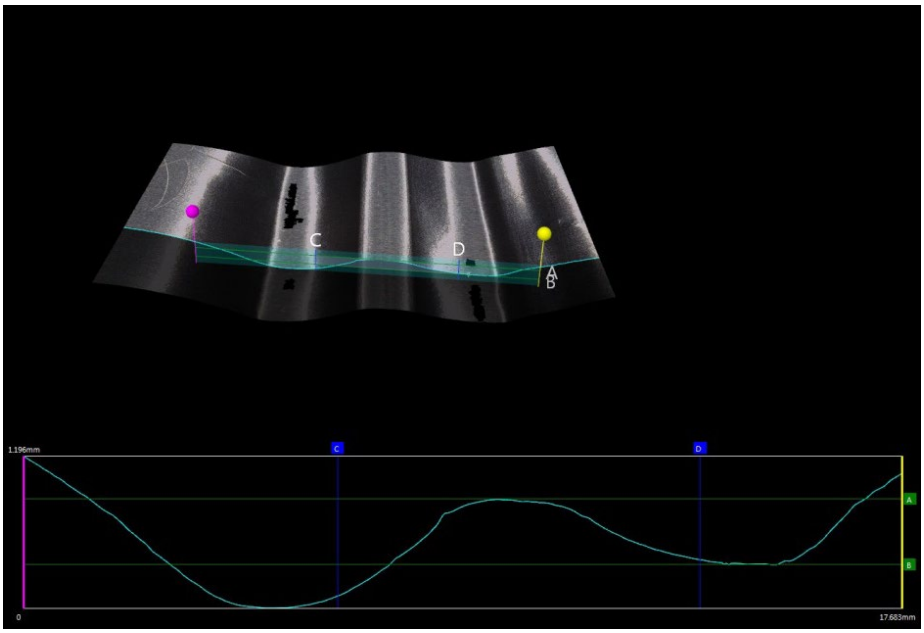


38. As shown below, a pair of forming portions are formed within the pouch film of LG Chem's Pouch Cell to house the electrode assembly:

LG Chem's Pouch Cell in the Jaguar I-PACE:



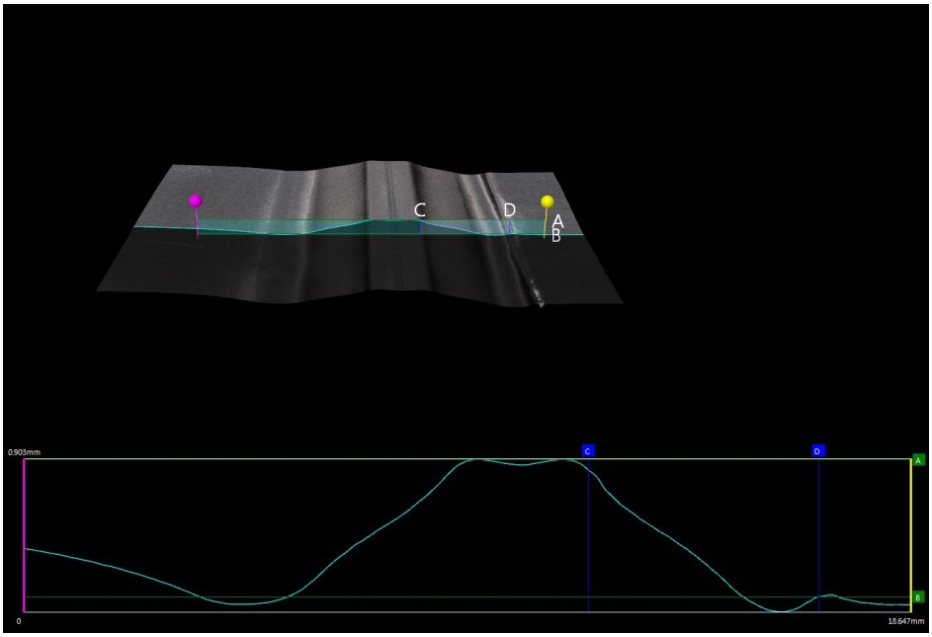
LG Chem's Pouch Cell in the Audi e-tron®:



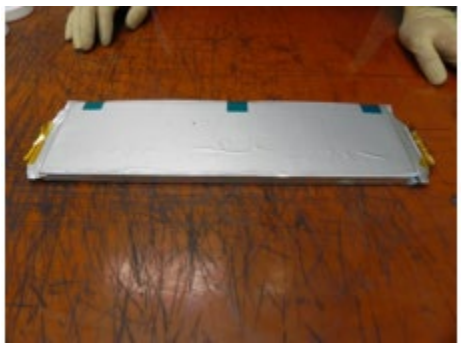
39. As shown below, the electrode assembly in LG Chem's Pouch Cell is packaged by the exterior material in a manner that three sides of the exterior material are sealed and one

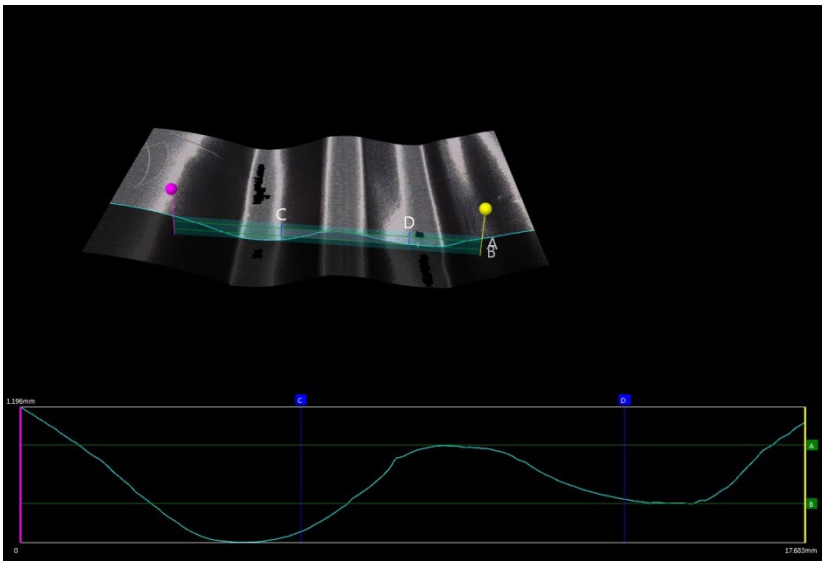
side is not sealed, and a thickness of the electrode assembly is larger than a sum of each depth of the pair of forming portions:

LG Chem's Pouch Cell in the Jaguar I-PACE:



LG Chem's Pouch Cell in the Audi e-tron®:





40. On information and belief, the batteries shown in paragraphs 36–39 above represent that batteries to be found in the Audi e-tron and Jaguar I-PACE vehicles imported into and on sale in the United States.

PRELIMINARY AND PERMANENT INJUNCTION

41. As a result of Defendants' unlawful activities, SK Innovation has suffered and will continue to suffer irreparable harm for which there is no adequate remedy at law. Defendants' continued infringement of the '994 Patent causes harm to SK Innovation in the form of price erosion, loss of goodwill, damage to reputation, loss of business opportunities, inadequacy of money damages, and direct and indirect competition. Monetary damages are insufficient to compensate SK Innovation for these harms. Accordingly, SK Innovation is entitled to preliminary and permanent injunctive relief.

DAMAGES

42. Under the law, SK Innovation is also entitled to compensation for Defendants' infringement described above. However, the full compensation owed to SK Innovation cannot be

ascertained except through discovery and special accounting. To the fullest extent permitted by law, SK Innovation seeks recovery of at least reasonable royalties. SK Innovation further seeks any other damages to which SK Innovation is entitled under law or in equity.

ATTORNEYS' FEES

43. SK Innovation is entitled to recover reasonable attorneys' fees under applicable law, including 35 U.S.C. § 285 given the exceptional nature of this case.

DEMAND FOR JURY TRIAL

44. SK Innovation hereby demands a trial by jury.

PRAYER FOR RELIEF

WHEREFORE, SK Innovation respectfully requests that this Court enter judgment in its favor that:

A. declares that LG Chem infringes the '994 Patent;

B. declares that Defendants' continued infringement of the '994 Patent is willful;

C. orders an accounting of damages;

D. awards SK Innovation damages in an amount adequate to compensate SK Innovation for Defendants' infringement of the '994 Patent, but in no event less than a reasonable royalty under 35 U.S.C. § 284, including supplemental damages for any continuing post-verdict infringement up until entry of the final judgment;

E. awards enhanced damages under 35 U.S.C. § 284;

F. awards SK Innovation pre-judgment and post-judgment interest to the full extent allowed under the law, as well as its costs;

G. awards a compulsory future royalty payable on each infringing product sold by Defendants following trial or that is not captured in the damages awarded to SK Innovation;

H. enters an order finding that this is an exceptional case and awarding SK Innovation its reasonable attorneys' fees under 35 U.S.C. § 285;

I. enters an order that preliminarily and permanently enjoins the Defendants and their officers, employees, agents, servants, attorneys, instrumentalities, and/or those in privity with them, from continuing to infringe the '994 Patent and for all further and proper injunctive relief under 35 U.S.C. § 283; and

J. awards such other relief as the Court may deem appropriate and just under the circumstances.

Dated: February 12, 2021

/s/ Adam W. Poff

Adam W. Poff (No. 3990)
Pilar G. Kraman (No. 5199)
YOUNG CONAWAY STARGATT & TAYLOR, LLP
Rodney Square
1000 North King Street
Wilmington, DE 19801
(302) 571-6600
apoff@ycst.com
pkraman@ycst.com

Attorneys for Plaintiff SK Innovation Co., Ltd.

OF COUNSEL:
Philip A. Irwin
Heng Gong
Sarah Mac Dougall
COVINGTON & BURLING LLP
The New York Times Building
620 Eighth Avenue
New York, New York 10018–1405
(212) 841–1000
pirwin@cov.com
hgong@cov.com
smacdougall@cov.com

Keith A. Teel
Peter A. Swanson
Daniel Farnoly

COVINGTON & BURLING LLP
One CityCenter, 850 Tenth Street, N.W.
Washington, DC 20001
Telephone: 202-662-6000
kteel@cov.com
pswanson@cov.com
dfarnoly@cov.com

Alice J. Ahn
COVINGTON & BURLING LLP
Salesforce Tower
415 Mission Street
San Francisco, CA 94105-2533
Telephone: 415-591-6000
aahn@cov.com

James D. Hovard
COVINGTON & BURLING LLP
3000 El Camino Real
5 Palo Alto Square, 10th Floor
Palo Alto, CA 94306
Telephone: 650-632-4700
jhovard@cov.com

EXHIBIT 1

US010121994B2

(12) **United States Patent**
Kang

(10) **Patent No.: US 10,121,994 B2**
(45) **Date of Patent: Nov. 6, 2018**

(54) **SECONDARY BATTERY AND METHOD FOR MANUFACTURING THE SAME**

(71) Applicant: **SK INNOVATION CO., LTD.**, Seoul (KR)

(72) Inventor: **Hee-Gyoung Kang**, Daejeon (KR)

(73) Assignee: **SK INNOVATION CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 24 days.

(21) Appl. No.: **15/196,703**

(22) Filed: **Jun. 29, 2016**

(65) **Prior Publication Data**

US 2016/0380245 A1 Dec. 29, 2016

(30) **Foreign Application Priority Data**

Jun. 29, 2015 (KR) 10-2015-0091847

(51) **Int. Cl.**

H01M 10/052	(2010.01)
H01M 2/02	(2006.01)
H01M 10/04	(2006.01)
H01M 2/10	(2006.01)
H01M 2/26	(2006.01)

(52) **U.S. Cl.**

CPC ***H01M 2/0267*** (2013.01); ***H01M 2/0207*** (2013.01); ***H01M 2/0275*** (2013.01); ***H01M 2/1016*** (2013.01); ***H01M 10/0431*** (2013.01); *H01M 2/263* (2013.01)

(58) **Field of Classification Search**

CPC H01M 10/052; H01M 10/0525

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0121963 A1* 5/2012 Kwon H01M 2/0275 429/127

FOREIGN PATENT DOCUMENTS

CN	102290536	12/2011
CN	206225480	6/2017
JP	2011096418	5/2011
KR	1020070102768	10/2007
KR	1020110065923	6/2011
KR	1020120008297	1/2012
KR	1020150061990	6/2015
WO	WO 2007/119950	10/2007

OTHER PUBLICATIONS

Notice of Allowance issued by the Korean Intellectual Property Office dated Nov. 13, 2017.

(Continued)

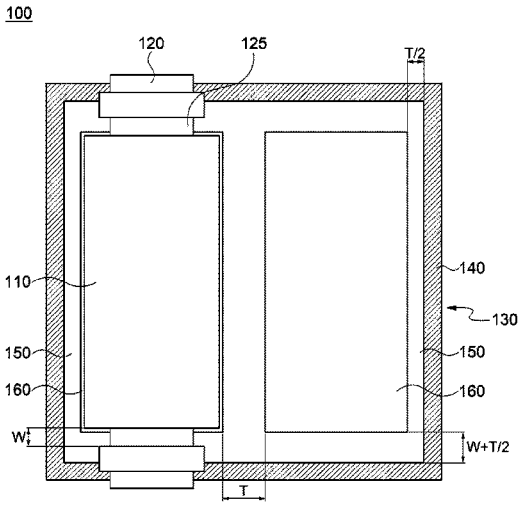
Primary Examiner — Olatunji A Godo

(74) *Attorney, Agent, or Firm* — IP & T Group LLP

(57) **ABSTRACT**

Disclosed are a secondary battery and a method for manufacturing the same. According to an embodiment of the present invention, there is provided a secondary battery, including: an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film; and an electrode assembly which includes a plurality of electrode bodies laminated with a separator interposed therebetween and are packaged by the exterior material, wherein a pair of forming portions are formed within the pouch film to house the electrode assembly, and a predetermined interval is formed between the pair of forming portions.

36 Claims, 4 Drawing Sheets



(56) **References Cited**

OTHER PUBLICATIONS

Office Action issued by the Korean Intellectual Property Office dated Mar. 22, 2016.
Office Action issued by the Korean Intellectual Property Office dated Aug. 5, 2016.
Office Action issued by the State Intellectual Property Office dated May 3, 2018.

* cited by examiner

FIG. 1

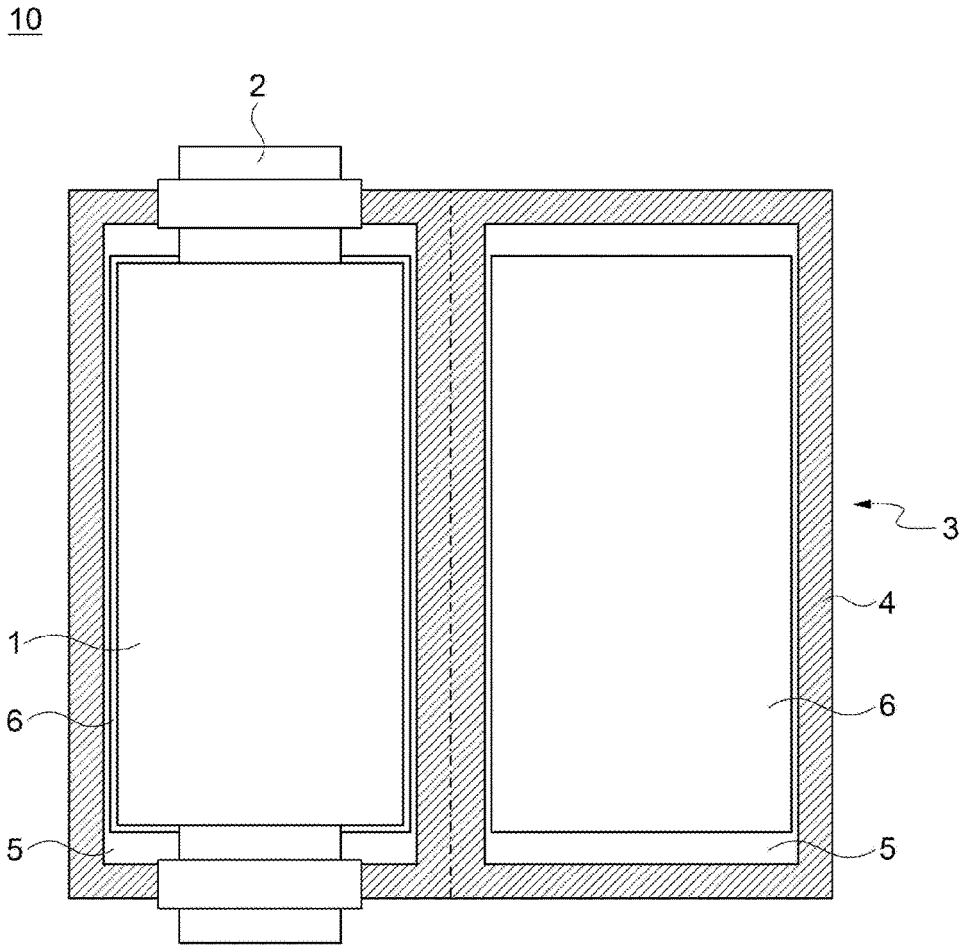


FIG. 2

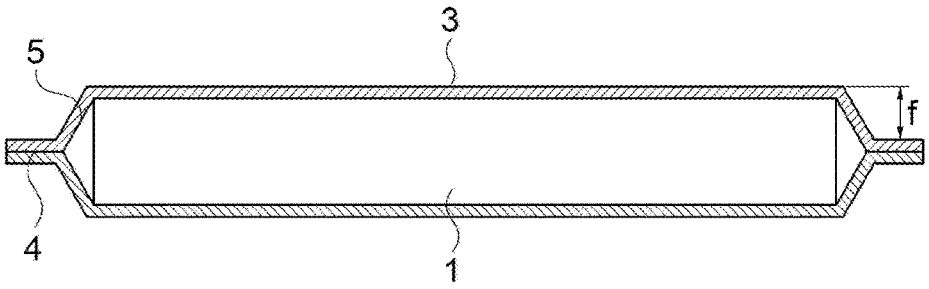


FIG. 3

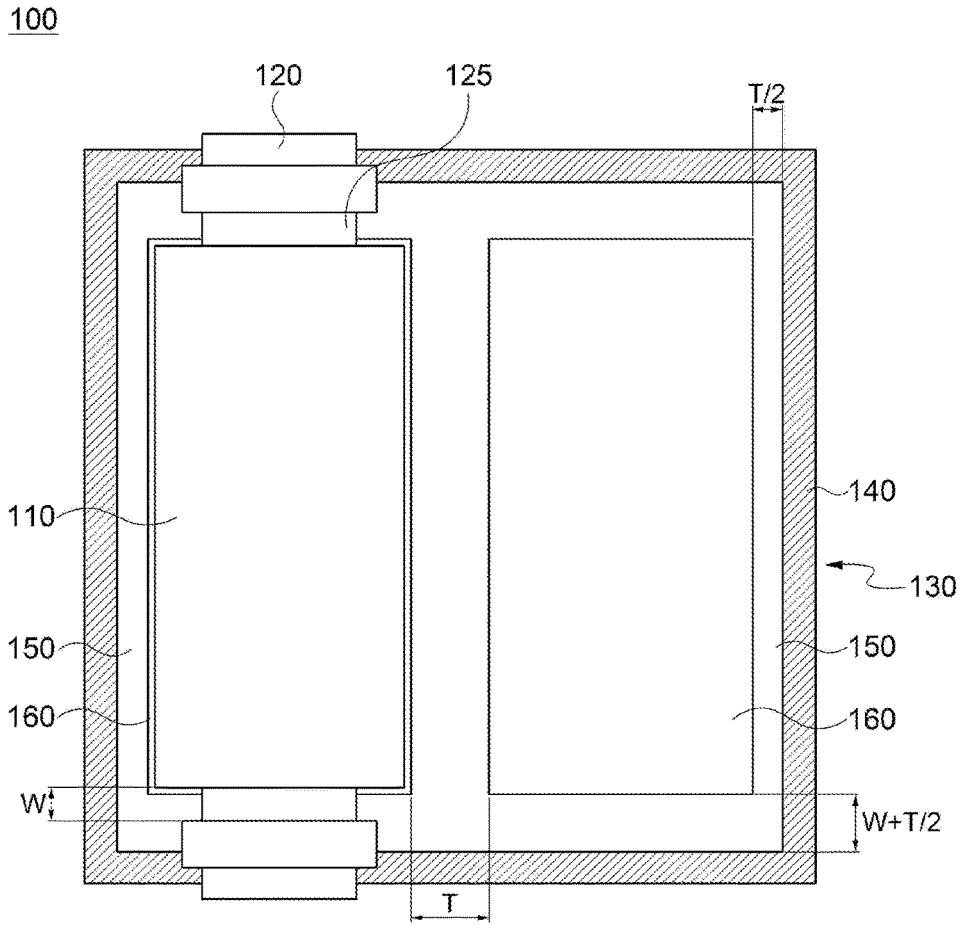


FIG. 4

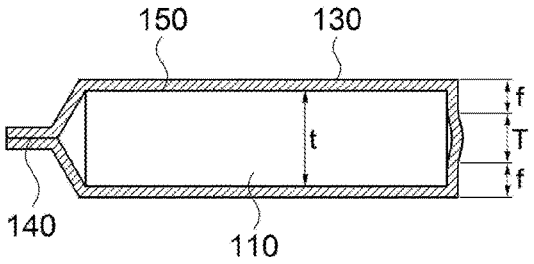
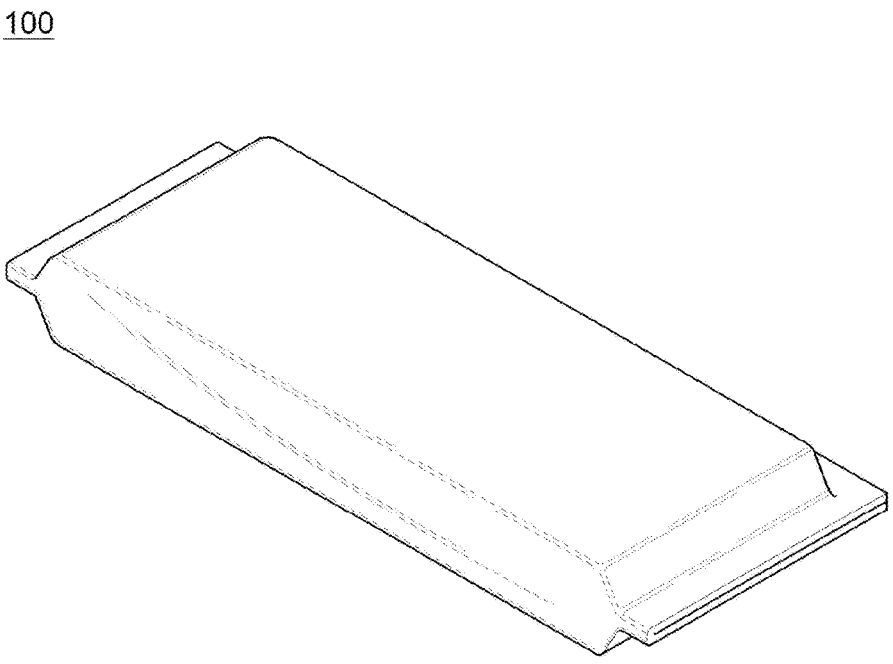


FIG. 5



SECONDARY BATTERY AND METHOD FOR MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a secondary battery and a method for manufacturing the same in embodiments thereof.

2. Description of the Related Art

Recently, a lithium secondary battery, which is rechargeable and lightweight and has a high energy and power density, has been widely used as an energy source for wireless mobile devices. Further, as a solution to the problems such as air pollution and the greenhouse house effect which are caused by existing internal combustion engine vehicles using fossil fuels such as a gasoline vehicle and a diesel vehicle, a hybrid electric vehicle (HEV), a plug-in hybrid electric vehicle (PHEV), a battery electric vehicle (BEV), an electric vehicle (EV), or the like have been proposed. The lithium secondary battery may serve as a power source for the alternative vehicles.

The lithium secondary battery is classified into a lithium ion battery using a liquid electrolyte and a lithium polymer battery using a polymer electrolyte in terms of a type of electrolytic solutions. The lithium secondary battery is also classified into cylindrical, prismatic, and a pouch shapes in terms of a shape of an exterior material in which an electrode assembly is housed.

Among these, the pouch type lithium secondary battery is made of a metal layer (foil) and a pouch film which is formed of multi-layered synthetic resin layers and coated on upper and lower surfaces of the metal layer, the weight of the pouch type lithium secondary battery may be remarkably lighter than that of the cylindrical lithium secondary battery or the prismatic lithium secondary battery using a metallic can. Thus, the pouch type lithium secondary battery may be lightweight and may be amenable to a change in shape.

FIG. **1** is a development view of a conventional pouch shape secondary battery **10** which is disclosed in Korean Patent Laid-Open Publication No. 10-2013-0089614 (2013 Aug. 12), and FIG. **2** is a cross-sectional view of the pouch shape secondary battery **10** of FIG. **1**.

Referring to FIGS. **1** and **2**, the pouch shape secondary battery **10** is formed by packaging an electrode assembly **1**, to which an electrode tab **2** is attached, with an exterior material **3**. The exterior material **3** includes a sealing portion **4** and a pair of pouch films **5**. Each of the pair of pouch films **5** includes a forming portion **6** to house the electrode assembly **1**. When a middle portion of the exterior material **3** is folded, upper and lower parts of the electrode assembly **1** are housed in the pair of forming portions **6**.

The forming portion **6** is formed by pressing an inside of the pouch film **5** with a press or the like to allow the pouch film **5** to have a predetermined depth. In this regard, the depth at which the forming portion **6** may be formed about 7 mm at maximum, and therefore a thickness of the electrode assembly **1** housed in the forming portion **6** has also a depth limitation (about 14 mm). Therefore, a capacity of the secondary battery **10** has a limitation.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a secondary battery and a method for manufacturing the same capable of increasing a thickness of a secondary battery cell in embodiments thereof.

Another object of the present invention is to provide a high-capacity secondary battery and a method for manufacturing the same by solving a limitation in a thickness of a secondary battery cell in embodiments thereof.

In addition, another object of the present invention is to provide a secondary battery and a method for manufacturing the same capable of actually increasing an energy density within the same volume by reducing a sealing side face in embodiments thereof.

According to one embodiment of the present invention, there is provided a secondary battery, including: an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film; and an electrode assembly which includes a plurality of electrode bodies stacked with a separator interposed therebetween and are packaged by the exterior material, wherein a pair of forming portions are formed within the pouch film to house the electrode assembly, and a predetermined interval is formed between the pair of forming portions.

The pair of forming portions may face each other with the electrode assembly interposed therebetween.

Each of the pair of forming portions may have a predetermined depth, and a thickness of the electrode assembly may have a relationship between the predetermined interval and a predetermined depth represented by Equation 1 below:

$$t \leq T+2f \quad \text{[Equation 1]}$$

Here, t denotes the thickness of the electrode assembly, T denotes the predetermined interval between the pair of forming portions, and f denotes the predetermined depths of each of the pair of forming portions.

The predetermined interval may be a range of exceeding from 0 mm but 20 mm or less.

Lateral intervals between the pair of forming portions and outermost parts of the pouch film may be a half (½) or more of the predetermined interval.

Both sides of the electrode assembly may be respectively provided with electrode tabs connected through a welding portion, and longitudinal intervals between the pair of forming portions and outermost parts of the pouch film may be a sum or more of the half (½) of the predetermined interval and a width of the welding part.

According to another embodiment of the present invention, there is provided a method for manufacturing a secondary battery, including: forming a pair of forming portions within a pouch film of an exterior material which includes the pouch film and a sealing portion formed at an outer side of the pouch film; housing an electrode assembly which includes a plurality of electrode bodies stacked with a separator interposed therebetween and packaged by the exterior material within the pair of forming portions; and sealing the sealing portions positioned at both sides with the electrode assembly interposed therebetween.

A predetermined interval may be formed between the pair of forming portions.

Each of the pair of forming portions may have a predetermined depth, and a thickness of the electrode assembly may have a relationship between the predetermined interval and a predetermined depth represented by Equation 1 below:

$$t \leq T+2f \quad \text{[Equation 1]}$$

Here, t denotes the thickness of the electrode assembly, T denotes the predetermined interval between the pair of forming portions, and f denotes the predetermined depths of each of the pair of forming portions.

The predetermined interval may be a range of exceeding from 0 mm but 20 mm or less.

Lateral intervals between the pair of forming portions and outermost parts of the pouch film may be a half (½) or more of the predetermined interval.

Both sides of the electrode assembly may be respectively provided with electrode tabs connected through a welding portion, and longitudinal intervals between the pair of forming portions and outermost parts of the pouch film may be a sum or more of the half (½) of the predetermined interval and a width of the welding part.

According to the embodiments of the present invention, it is possible to increase the thickness of the secondary battery cell by forming the pair of forming portions within one pouch film and forming a predetermined interval between the pair of forming portions.

According to the embodiments of the present invention, it is possible to manufacture the high-capacity secondary battery by solving the limitation in the thickness of the secondary battery cell.

Further, according to the embodiment of the present invention, it is possible to actually increase the energy density within the same volume by reducing the sealing side face.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a development view of a conventional pouch type secondary battery;

FIG. **2** is a cross-sectional view of the pouch type secondary battery of FIG. **1**;

FIG. **3** is a development view of a secondary battery according to an embodiment of the present invention;

FIG. **4** is a cross-sectional view of a secondary battery according to an embodiment of the present invention; and

FIG. **5** is a perspective view of a secondary battery according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, specific embodiments of the present invention will be described with reference to the accompanying drawings. But, these are only an example, and the present invention is not limited thereto.

In description of the present invention, detailed description of the publicly known functions and configurations that are judged to be able to make the purport of the present invention unnecessarily obscure are omitted. In addition, terms or words used in the specification and claims should not be construed as limited to a lexical meaning, and should be understood as appropriate notions by the inventor based on that he/she is able to define terms to describe his/her invention in the best way to be seen by others.

However, those skilled in the art will appreciate that such embodiments are provided for illustrative purposes and do not limit subject matters to be protected as disclosed in the detailed description and appended claims. Therefore, it will be apparent to those skilled in the art that various alterations and modifications of the embodiments are possible within the scope and spirit of the present invention and duly included within the range as formed by the appended claims.

FIG. **3** is a development view of a secondary battery **100** according to an embodiment of the present invention.

Referring to FIG. **3**, the secondary battery **100** includes an electrode assembly **110** including a plurality of electrode bodies which are stacked and a separator interposed between the plurality of electrode bodies. To package the electrode assembly **110**, an exterior material **130** including a pouch film **150** and a sealing portion **140** formed on an outer circumference of the pouch film **150** may be used.

The secondary battery **100** may be a pouch type secondary battery. The electrode assembly **110** may be a jelly roll in an oval shape or the like in which cathode plates and anode plates are alternately stacked with each other with the separator interposed therebetween. Both ends of the electrode assembly **110** have electrode tabs **120**, and welding portions **125** may be formed between the electrode tab **120** and the electrode assembly **110** to connect these parts with each other.

The pouch film **150** may include aluminum. The reason of using the aluminum in the pouch film **150** is to resist severe thermal environments, mechanical impacts, or the like as well as to achieve miniaturization, weight reduction, and slimness.

The pouch film **150** includes a pair of forming portions **160** for housing the electrode assembly **110**. The forming portion **160** may be in a recessed shape, and may be formed by pressing the inside of the pouch film **150** or the like.

However, when the forming portion **160** is pressed too hard, the pouch film **150** may be damaged, and therefore the depth of the forming portion **160** is limited. As a result, in the conventional secondary battery, the thickness of the electrode assembly **110** housed in the forming portion **160** is also limited due to the limitation in the depth of the forming portion **160**.

According to the embodiments of the present invention, the pair of forming portions **160** may be formed in the pouch film **150**, and a predetermined interval T may be formed between the pair of forming portions **160**. Further, the secondary battery may be formed by placing one side of the electrode assembly **110** within one forming portion **160**, and then wrapping the other side of the electrode assembly **110** with the other forming portion **160**. An extra space is additionally generated as much as the predetermined interval T formed between the pair of forming portions **160**, and thus the thickness of a space, in which the electrode assembly **110** is received, may be increased as much as the predetermined interval T.

Herein, the pair of forming portions **160** may face each other and the electrode assembly **110** is interposed therebetween. Further, the predetermined interval may be in a range between 0 mm, exclusive, and 20 mm, inclusive.

As illustrated in FIG. **3**, a lateral distance between each of the pair of forming portions **160** and the sealing portion **140** may a half (½) or more of the predetermined interval T. When the pouch film **150** is wrapped, the pair of forming portions **160** and both sides of the outermost part of the pouch film **150** abut each other. Therefore, it is preferable that each of the lateral intervals is the half (½) or more of the predetermined interval T.

Further, a longitudinal distance between each of the forming portions **160** and the outermost part of the pouch film **150** may be W+T/2 or more. Here, W is a width of the welding portion **125**.

FIG. **4** is a cross-sectional view of the secondary battery **100** according to the embodiment of the present invention. Referring to FIG. **4**, the secondary battery **100** may be formed by packaging the electrode pouch **110** with the exterior material **130** including the pouch film **150**. The

secondary battery **100** may be sealed with a sealing portion **140** formed at an outer side of the exterior material **130**.

A thickness t of the electrode assembly **110** within the secondary battery **100** may be represented by Equation 1 below:

$$t \leq T+2f \quad \text{[Equation 1]}$$

Here, f is a depth of each of the forming portions **160**.

The above relationship Equation 1 may be expressed as illustrated in FIG. **4**. Therefore, the thickness t of the electrode assembly **110** may be thicker than the conventional secondary battery, and it is possible to manufacture the secondary battery **100** having a thickness of 14 mm or more that may not be achieved in the related art.

Further, as illustrated in FIG. **4**, only one of two long edges of the secondary battery **100** may be sealed with the sealing portion **140**. Therefore, the energy density within the same volume may be increased as much as the sealed surface is reduced.

FIG. **5** is a perspective view of the secondary battery **100** according to the embodiment of the present invention.

Referring to FIG. **5**, in the secondary battery **100** of the present invention, the thickness of the electrode assembly **110** is not limited due to a depth of the forming portion **160**. The thickness of the electrode assembly **110** may be formed thicker due to the interval present between the forming portions **160**. Thereby, the capacity of the secondary battery **100** may be increased. Further, the energy density may be actually increased by reducing a sealing area of the secondary battery **100**.

Hereinafter, a method for manufacturing a secondary battery **100** according to an embodiment of the present invention will be described.

First, the pouch film **150** and the exterior material **130** including the sealing portion **140** formed at the outer side of the pouch film **150** may be prepared. The pair of forming portions **160** may be formed within the pouch film **150**. The predetermined interval may be formed between the pair of forming portions **160** and the predetermined interval may be in a range between 0 mm, exclusive, and 20 mm, inclusive. Further, the interval between each of the pair of forming portions **160** and the sealing portion **140** may a half (½) or more of the predetermined interval.

Next, the electrode assembly **110** may be housed within the pair of forming portions **160**. In this case, the secondary battery may be formed by placing the electrode assembly **110** over one forming portion **160**, and then wrapping the electrode assembly **110** with the other forming portion **160**. Therefore, the extra space is additionally generated as much as the predetermined interval T, which is a distance between the forming portions **160**. Thus, the thickness of the electrode assembly **110** may be increased as much as the predetermined interval T.

Further, the sealing portions **140** are attached to each other so that the electrode assembly **110** is enclosed within the pouch film **150**.

While the present invention has been described with reference to the preferred embodiments, it will be understood by those skilled in the related art that various modifications and variations may be made therein without departing from the scope of the present invention as formed by the appended claims. Therefore, the scope of the present invention should not be formed by the described embodiment but should be formed by the appended claims and their equivalents.

DESCRIPTION OF REFERENCE NUMERALS

100: secondary battery
110: electrode assembly
120: electrode tab
125: welding portion
130: exterior material
140: sealing portion
150: pouch film
160: forming portion

What is claimed is:

1. A secondary battery, comprising:
an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film; and
an electrode assembly which includes a plurality of electrode bodies laminated with a separator interposed therebetween,
wherein a pair of forming portions are formed within the pouch film to house the electrode assembly, and
wherein the electrode assembly is packaged by the exterior material in a manner that three sides of the exterior material are sealed and one side is not sealed, and a thickness of the electrode assembly is larger than a sum of each depth of the pair of forming portions.

2. The secondary battery of claim **1**, wherein the pair of forming portions face each other with the electrode assembly interposed therebetween.

3. The secondary battery of claim **1**, wherein a predetermined interval is formed between the pair of forming portions, and
wherein a thickness of the electrode assembly has a relationship between the predetermined interval and a predetermined depth represented by Equation 1 below:

$$t \leq T+2f \quad \text{[Equation 1]}$$

wherein t denotes the thickness of the electrode assembly, T denotes the predetermined interval between the pair of forming portions, and f denotes the predetermined depths of each of the pair of forming portions.

4. The secondary battery of claim **3**, wherein the predetermined interval is greater than 0 and equal to or less than 20 mm.

5. The secondary battery of claim **1**, wherein lateral intervals between the pair of forming portions and the sealing portion are a half (½) or more of the predetermined interval.

6. The secondary battery of claim **1**, wherein both sides of the electrode assembly are respectively provided with electrode tabs connected through a welding portion, and
wherein longitudinal intervals between the pair of forming portions and the sealing portion are a sum or more of the half (½) of the predetermined interval and a width of the welding part.

7. The secondary battery of claim **1**, wherein the side of the exterior material that is not sealed is a folded side.

8. The secondary battery of claim **7**, wherein an inclination angle by the exterior material at an edge of the electrode assembly positioned at the sealed side is larger than an inclination angle by the exterior material at an edge of the electrode assembly positioned at the folded side.

9. The secondary battery of claim **7**, wherein an inclination angle by the exterior material at an edge of the electrode assembly positioned at the folded side is 90~95 degrees.

10. The secondary battery of claim **7**, wherein the electrode assembly and the exterior material at the folded side are in contact with each other.

11. The secondary battery of claim **1**,
wherein the pouch film is formed of a single body and is in a folded shape,

wherein a first area, a second area, a third area, a fourth area, and a fifth area are sequentially arranged between a first edge and a second edge of the pouch film in a first direction,

wherein the first area and the fifth area, in combination, form a first sidewall of the exterior material,

wherein the second area forms a bottom layer of the exterior material,

wherein the third area forms a second sidewall of the exterior material,

wherein the fourth area forms an upper layer of the exterior material,

wherein the sealing portion is provided over the first edge, the second edge, or both,

wherein the first edge and the second edge meet each other on the first sidewall and are bonded to each other by the sealing portion,

wherein a first forming portion is formed in the second area of the pouch film and protrudes downward by a first thickness f1,

wherein a second forming portion is formed in the fourth area of the pouch film and protrudes upward by a second thickness f2,

wherein the electrode assembly is located between the first and the second forming portions and has a third thickness t, and

wherein the third thickness t of the electrode assembly is larger than a sum of the first thickness f1 and the second thickness f2.

12. The secondary battery of claim **11**,

wherein the first and the second forming portions face each other.

13. The secondary battery of claim **11**,

wherein the third area of the pouch film has a first width T when measured along the first direction,

wherein the first thickness f1 is the same as the second thickness f2, and

wherein the third thickness t of the electrode assembly satisfies the following Equation

$$t \leq T+2f$$

wherein f=f1=f2.

14. The secondary battery of claim **13**,

wherein a width of the first area is between T/2 and T, inclusive, when measured along the first direction, and

wherein a width of the fifth area is between T/2 and T, inclusive, when measured along the first direction.

15. The secondary battery of claim **13**, further comprising:

an electrode tab provided between the electrode assembly and an outside of the pouch film; and

a welding portion coupling the electrode assembly to the electrode tab,

wherein the pouch film extends from a third edge through a sixth area, the second area, and a seventh area to a fourth edge in a second direction,

wherein the second direction is different from the first direction,

wherein the welding portion has a width W when measured along the second direction, and

wherein a width of the sixth area of the pouch film is the same as or larger than (W+T/2).

16. The secondary battery of claim **11**,

wherein the first sidewall of the exterior material is formed with a seam, the seam being created by bonding the first edge and the second edge using the sealing portion, and

wherein the second sidewall of the exterior material is formed seamless and without using the sealing portion.

17. The secondary battery of claim **16**,

wherein the first sidewall has a first inclination with respect to the bottom layer,

wherein the second sidewall has a second inclination with respect to the bottom layer, and

wherein the second inclination is larger than the first inclination.

18. The secondary battery of claim **16**, wherein the electrode assembly directly contacts the second sidewall of the exterior material.

19. A secondary battery, comprising:

an exterior material which includes a pouch film and a sealing portion formed at an outer side of the pouch film; and

an electrode assembly which includes a plurality of electrode bodies laminated with a separator interposed therebetween and are packaged by the exterior material,

wherein a pair of forming portions are formed within the pouch film to house the electrode assembly,

wherein the exterior material packages the electrode assembly in a manner that three sides of the exterior material are sealed, and one side is not sealed, and

wherein a space between the electrode assembly and the side of the exterior material that is not sealed is smaller than a space between the electrode assembly and at least one of the sides of the exterior material that are sealed.

20. The secondary battery of claim **19**,

wherein the side that is not sealed is a side that the exterior material is folded around the electrode assembly,

wherein a side that faces the side that is not sealed is a side that exterior material is sealed, and

wherein the space between the side that is not sealed and the electrode assembly is smaller than a space between the side that faces the side that is not sealed and the electrode assembly.

21. The secondary battery of claim **19**, wherein the pair of forming portions face each other with the electrode assembly interposed therebetween.

22. The secondary battery of claim **19**, wherein a predetermined interval is formed between the pair of forming portions, and

wherein a thickness of the electrode assembly has a relationship between the predetermined interval and a predetermined depth represented by Equation 1 below:

$$t \leq T+2f \quad \text{[Equation 1]}$$

wherein t denotes the thickness of the electrode assembly, T denotes the predetermined interval between the pair of forming portions, and f denotes the predetermined depths of each of the pair of forming portions.

23. The secondary battery of claim **22**, wherein the predetermined interval is greater than 0 mm and equal to or less than 20.

24. The secondary battery of claim **22**, wherein lateral intervals between the pair of forming portions and the sealing portion are a half (½) or more of the predetermined interval.

25. The secondary battery of claim **19**, wherein the electrode assembly is provided with electrode tabs connected through a welding portion, and

wherein longitudinal intervals between the pair of forming portions and the sealing portion are a sum or more of the half (½) of the predetermined interval and a width of the welding part.

26. The secondary battery of claim **19**, wherein an inclination angle of sealed side of the exterior material is larger than an inclination angle of the non-sealed side.

27. The secondary battery of claim **19**, wherein the inclination angle of the non-sealed side is 90~95 degrees.

28. The secondary battery of claim **26**, wherein the electrode assembly and the non-sealed side of the exterior material are in at least partial contact.

29. The secondary battery of claim **19**,

wherein the pouch film is formed of a single body and is in a folded shape,

wherein a first area, a second area, a third area, a fourth area, and a fifth area are sequentially arranged between a first edge and a second edge of the pouch film in a first direction,

wherein the first area and the fifth area, in combination, form a first sidewall of the exterior material,

wherein the second area forms a bottom layer of the exterior material,

wherein the third area forms a second sidewall of the exterior material,

wherein the fourth area forms an upper layer of the exterior material,

wherein the sealing portion is provided over the first edge, the second edge, or both,

wherein the first edge and the second edge meet each other on the first sidewall and are bonded to each other by the sealing portion,

wherein a first forming portion is formed in the second area of the pouch film and protrudes downward by a first thickness f1,

wherein a second forming portion is formed in the fourth area of the pouch film and protrudes upward by a second thickness f2,

wherein the electrode assembly is located between the first and the second forming portions and has a third thickness t, and

wherein the third thickness t of the electrode assembly is larger than a sum of the first thickness f1 and the second thickness f2.

30. The secondary battery of claim **29**,

wherein the first and the second forming portions face each other.

31. The secondary battery of claim **29**,

wherein the third area of the pouch film has a first width T when measured along the first direction,

wherein the first thickness f1 is the same as the second thickness f2, and

wherein the third thickness t of the electrode assembly satisfies the following Equation 1:

$$t \leq T+2f \quad \text{[Equation 1]}$$

wherein f=f1=f2.

32. The secondary battery of claim **31**,

wherein a width of the first area is between T/2 and T, inclusive, when measured along the first direction, and

wherein a width of the fifth area is between T/2 and T, inclusive, when measured along the first direction.

33. The secondary battery of claim **31**, further comprising:

an electrode tab provided between the electrode assembly and an outside of the pouch film; and

a welding portion coupling the electrode assembly to the electrode tab,

wherein the pouch film extends from a third edge through a sixth area, the second area, and a seventh area to a fourth edge in a second direction,

wherein the second direction is different from the first direction,

wherein the welding portion has a width W when measured along the second direction, and

wherein a width of the sixth area of the pouch film is the same as or larger than (W+T/2).

34. The secondary battery of claim **29**,

wherein the first sidewall of the exterior material is formed with a seam, the seam being created by bonding the first edge and the second edge using the sealing portion, and

wherein the second sidewall of the exterior material is formed seamless and without using the sealing portion.

35. The secondary battery of claim **34**,

wherein the first sidewall has a first inclination with respect to the bottom layer,

wherein the second sidewall has a second inclination with respect to the bottom layer, and

wherein the second inclination is larger than the first inclination.

36. The secondary battery of claim **34**, wherein the electrode assembly directly contacts the second sidewall of the exterior material.

* * * * *